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Potential Campaign Architectures and Mission design challenges for near-term international Mars Sample Return mission concepts AAS 19-583

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Presented by:
Rob Lock
Development Manager, Mars Program Formulation Office
NASA Jet Propulsion Laboratory

Authors:
Robert E. Lock, Austin K. Nicholas, Sanjay Vijendran, Ryan C. Woolley, Alan Didion, Frank Laipert, Zubin Olikara

Introduction

- MSR mission studies have been studied since the Viking landings in 1978
- This presentation introduces the current international MSR study architecture
- Introduces the subjects of the other 5 papers presented at this conference that represent work done for this architecture and study for a potential mission

The MSR coordinated papers

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- The JPL MSR study team members have written 6 papers for this conference
- They describe the notional MSR architecture (this one) and take on some of the difficult aspects of MSR, especially those that are new to the architecture, including:
  - Methods for constructing optimal trajectories to and from Mars using electric propulsion and hybrid chemical-electric propulsion trajectories
  - Methods for co-optimizing the S/C design and trajectory – necessary for EP missions
  - Methods for constructing an MSR campaign in the face of complex and highly varied constraints and stakeholder concerns
  - New analysis for rendezvous concepts of OS detection and orbit matching

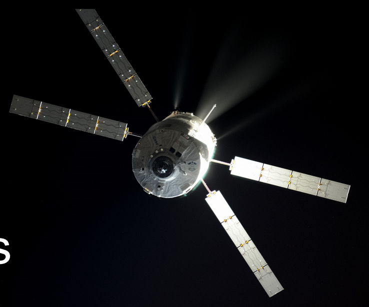
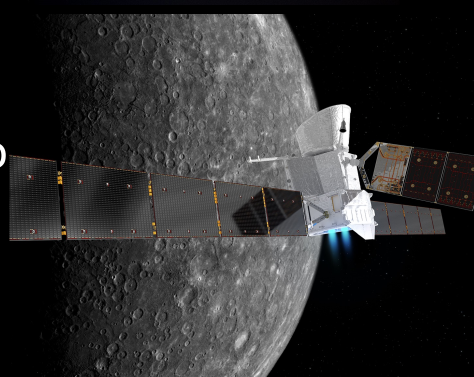
- The other topics are:
  - Ryan Woolley will discuss Low-Thrust Trajectory Bacon Plots
  - Frank Laipert will talk about Hybrid Chemical-Electric Trajectories for a MSR Orbiters
  - Eric Gustafson will discuss Mars Orbital Rendezvous Detection Methods
  - Zubin Olikara will talk about how we look at Rendezvous Orbit Matching with chemical and electric propulsion
  - Austin Nicholas will talk about both the simultaneous optimization of S/C and trajectories using Solar Electric Propulsion as well as the mission analysis for our MSR Campaign concepts

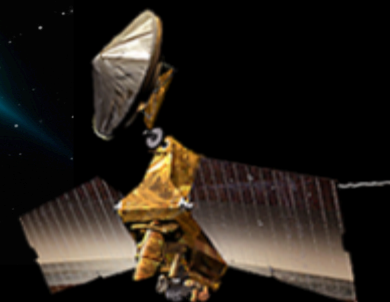
MSR Background

- Post-Viking Science community stresses Mars in-situ and sample return goals and priorities
- Sally Ride Report calls for Mars Sample Return in the late 1980s.
  - Mars Rover Sample Return pre-project begun
- International Partnerships stressed in the late 1990s
  - MSR project begun with CNES partnership in 1997
- NASA/ESA partnership studies begin in the late 2000s
  - ExoMars partnership was first collaboration
- Discussions of partnerships leading to the current study started in 2017
  - Current partnership Statement of Intent, April 2018

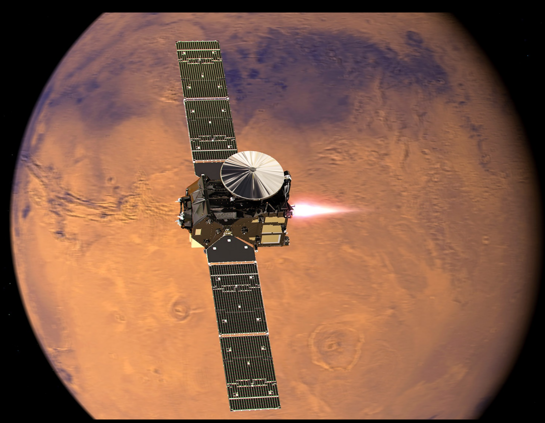
20 years of Experience

- TGO
- Mars Express
- Venus Express
- Smart-1
- Rosetta
- BepiColombo
- ATV

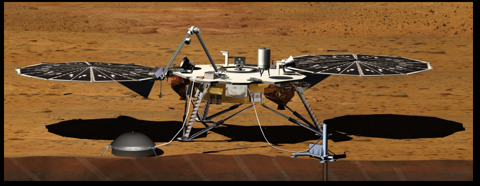



- Odyssey
- MRO
- Dawn
- Phoenix
- MSL
- MAVEN
- InSight

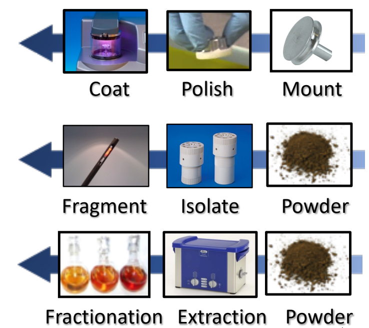




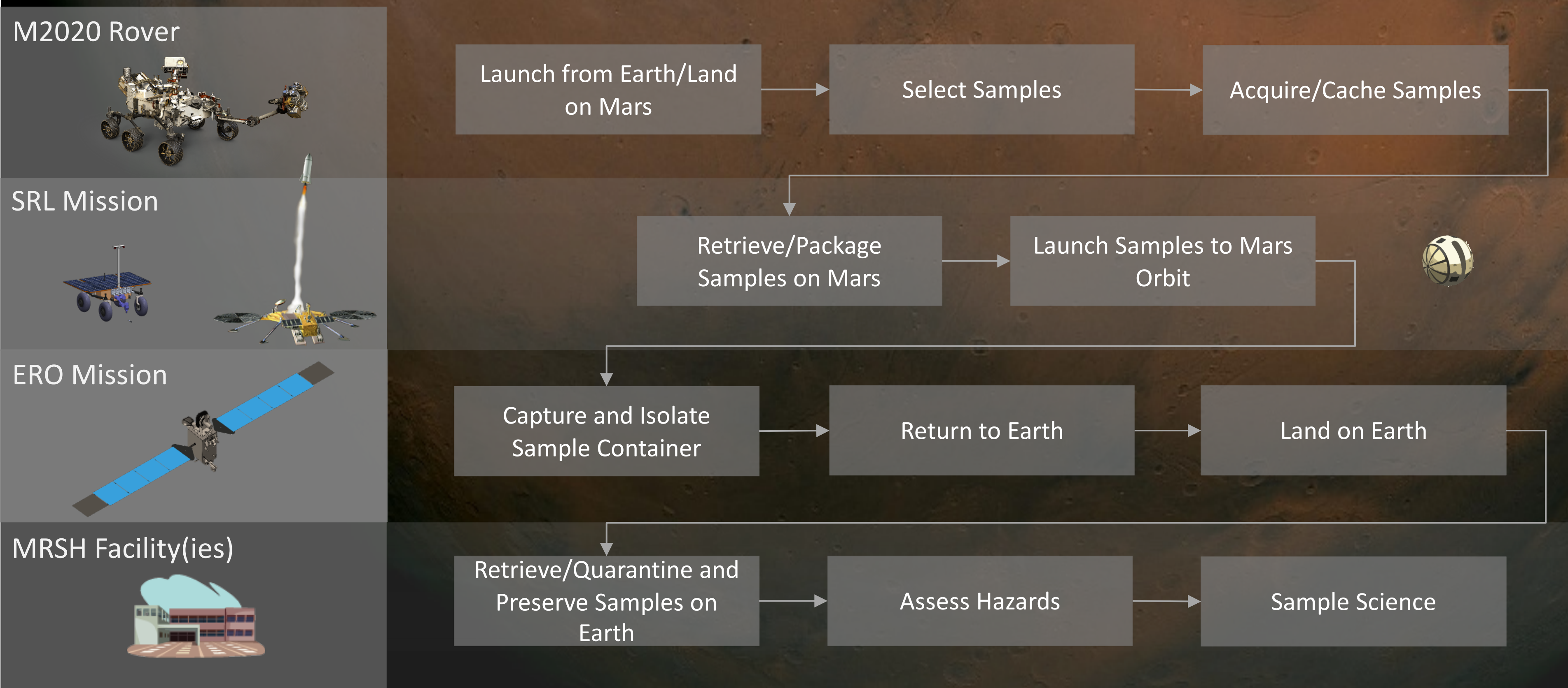


Notional MSR Campaign – Functional Objectives

- **Acquire and return to Earth** a scientifically selected set of **Mars samples** for investigation in **terrestrial laboratories**
- Select samples based on their **geologic diversity**, **astrobiological relevance**, and **geochronologic significance**
- **Establish the field context** for each sample using ***in situ* observations**
- Ensure the **scientific integrity** of the returned samples through **contamination control** (including round-trip Earth contamination and sample-to-sample cross-contamination) and **control of environments** experienced by the samples after acquisition
- **Ensure compliance with planetary protection requirements** associated with the return of Mars samples to Earth's biosphere
- Achieve a set of **sample-related scientific objectives**
  - *Life* • *Geologic environments* • *Geochronology* • *Volatiles*
  - *Planetary-scale geology* • *Environmental hazards* • *ISRU*



Notional MSR Campaign Architecture



Pre-Decisional information - For planning and discussion purposes only.

Notional MSR Mission Scenario and Roles

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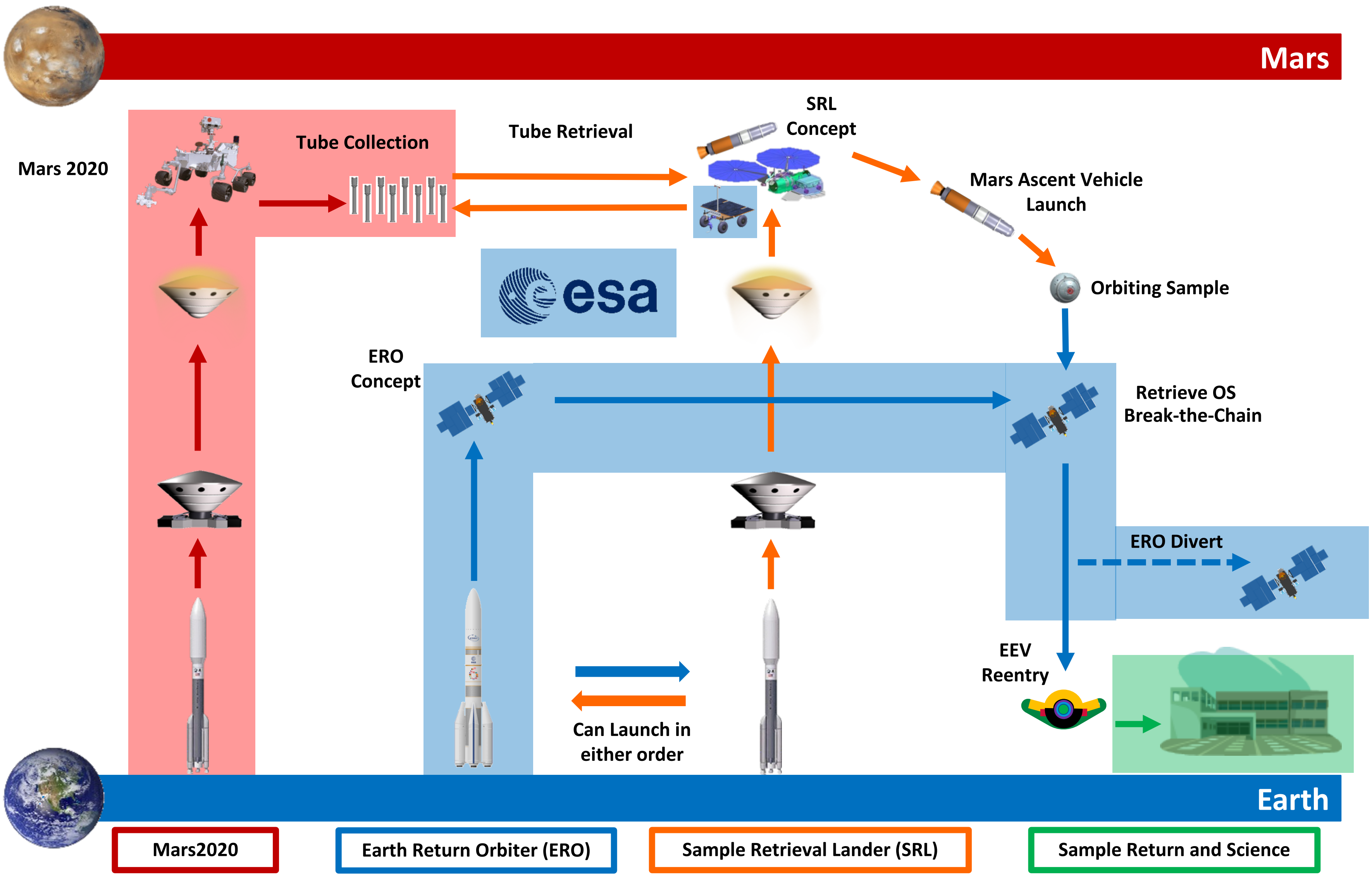
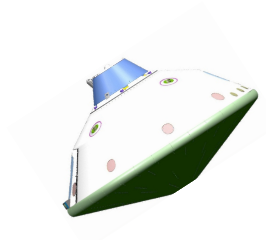
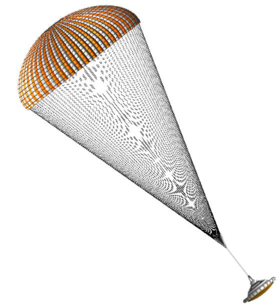


Lander Concepts Options Under Study (1/2)

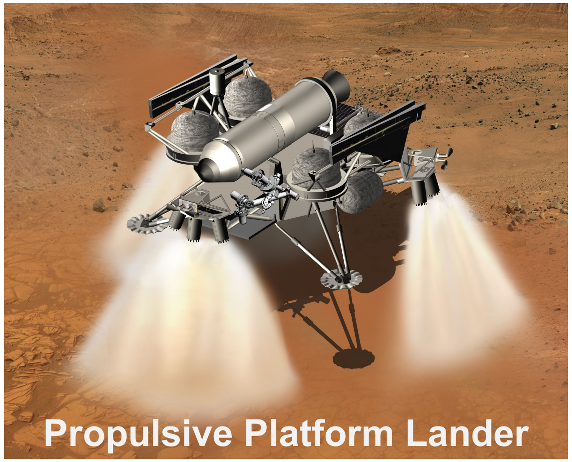
Mission Objectives:

- Land on Mars
- Deploy the Sample Fetch Rover
- Maintain the lander and MAV within safe operating conditions
- Once the SFR returns with the tubes, SRL must:
  - Transfer tubes to the OS in the MPA, using the STA
  - Assemble the MPA to the MAV
  - Prepare the MAV for launch (heat and erect)
  - Launch the MAV
- Most of Entry, Descent and Landing is common to both options and based on Mars Science Laboratory





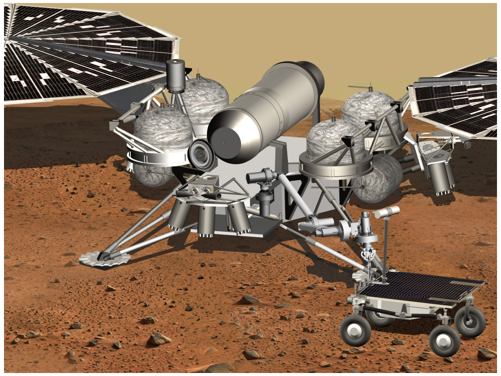
Skycrane Delivered Lander



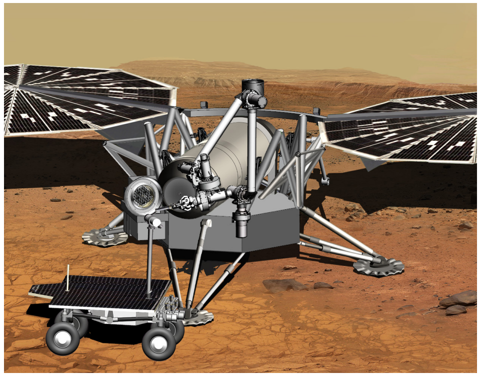
Propulsive Platform Lander

Lander Concepts Options Under Study (2/2)

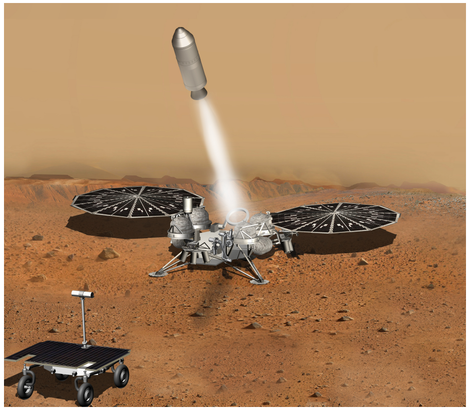
- **Key Study Elements**
  - Accommodation of MAV (400 kg) and Fetch Rover (120 kg) on lander in aeroshell, with volume and mass margins
  - Solar power and thermal design for worst case environments
  - MAV propulsion technology, performance (including mass), and reliability
  - OS: Tube accommodation, insertion into MAV
  - Planetary protection design and implementation strategies

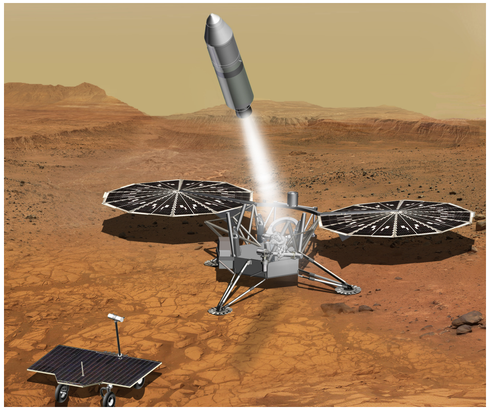


Propulsive Platform Lander



Skycrane Delivered Lander

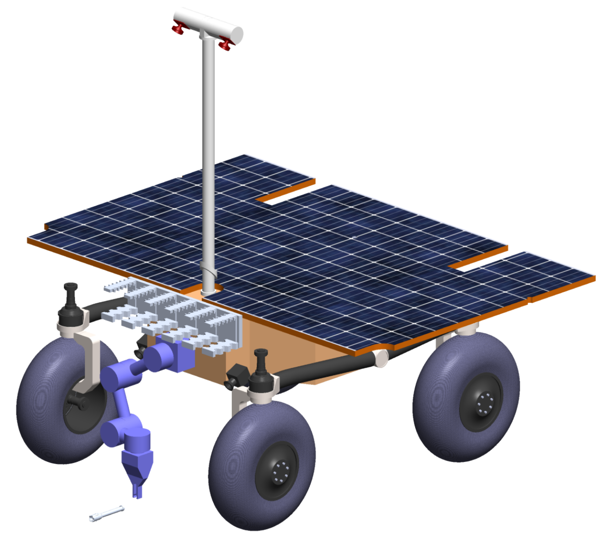




Fetch Rover Concept

- **Mission Objectives**
  - Acquire sample tubes cached by M2020 and deliver them to the SRL
- **Key Specifications (based on NASA conceptual design)**
  - Rover Mass: 120 kg (Not to Exceed)
  - Egress Mass: 25 kg (Not to Exceed)
  - Stowed Volume: ~1 m^3
- **ESA Implementation**
  - Two parallel competitive contracts: Thales Alenia Space, Italy and Airbus Defence and Space, UK
  - ExoMars 2020 heritage: triple bogie, six wheel approach
  - Technology development: Mars Robotic Exploration Program (MREP) for GNC, miniaturised avionics, as well as low temperature mechanisms and batteries.

Current NASA Fetch Rover Concept



Scale is roughly 2/3 of MER

ERO Mission Concept Profile

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